http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5(3): 263-265, 2002

Effect of Ripping and Water Head on Infiltration Rate of Soils in Saudi Arabia

Abdullah A. Al-Ghazal
Department of Agricultural Engineering, College of Agriculture and Food Sciences, King Faisal University, P.O. Box -762, Al-Hassa 31982, Kingdom of Saudi Arabia

Abstract: A field trial was conducted to study the effect of ripping and water head on infiltration rate of sandy-loam and clay-loam soils during Summer, 2001. The treatments involved ripping of soil with chisel plough up to 60-90 cm depth of soil with four water head treatments ranging from 5 to 20 cm depth of irrigation water. The difference in infiltration rate of soil between ripping and control treatments was significant. Mean infiltration rate of sandy loam soil ranged between 4.35-8.13 cm hr^{-1} (control treatment) and 5.79-13.72 cm hr^{-1} in the ripping treatment in different water head treatments. Similarly, mean infiltration rate of clay loam soil ranged between 1.51-3.28 cm hr^{-1} (control) and 2.23-4.76 cm hr^{-1} (ripping) in different water head treatments. Ripping of soil and water head significantly increased the infiltration rate of soil than the control treatment. The magnitude of increase in the infiltration rate was 132-163 % in sandy loam soil and 136-146 % in clay loam soil in various treatments. In conclusion, ripping improved the infiltration rate of soil thus providing an opportunity for speedy reclamation of salt affected lands where hardpan is a major limitation for salt leaching. The positive effect of ripping and increasing water head on infiltration rate of soil warrants the scientific irrigation scheduling and precision land leveling to avoid unnecessary water losses for efficient water management and conservation in an arid environment.

Key words: Ripping, sandy loam, clay loam, infiltration rate, water head, Saudi Arabia

Introduction

Infiltration rate of soil is important and directly affects the soil and water management. Scientific water management is conducive to many arid and semiarid countries of the world such as Kingdom of Saudi Arabia, where irrigation supplies are inadequate and precipitation is unpredictable and scanty. In Saudi Arabia, the infiltration rate of a number of soils has been measured as affected by tillage practice and machinery compaction (Abo-Abda and Hussain, 1991; Al-Ghazal, 2000).

The infiltration rate of soil is affected by a number of factors such as soil type, presence of hard layer, depth to groundwater table, nature of soil profile, farm machinery compaction, and conditions of soil surface. The soil infiltration rate increased significantly in the tillage plots than the control plots (Abu Abda and Hussain, 1991). Recently, Al-Ghazal (2000) found that soil compaction with farm machinery caused significant reduction in infiltration rate of soils. Pikul *et al.* (1992), using a rain simulator, found that contour ripping increased water infiltration into frozen soil during the winter crop. Wilkins *et al.* (1991) developed a special tillage tool to create tillage channels through the frozen soils with minimum soil disturbance to improve the water infiltration rate .

Eric (1962) observed significant differences in water infiltration of soils between water head of 2.5 cm to 15 cm on high infiltration rate soils. Schiff (1953) and Aronovici (1955) stated that an increase in infiltration rate of soils was directly proportional to an increase in water head. However, Philip (1958) reported that the effect of depth of water about the soil surface on infiltration rate decreases gradually with time. Extensive review of literature indicates that a very little research work has been accomplished on the effect of depth of irrigation water applied on the infiltration rate of soils which needs consideration. Because, the depth of water during and after irrigation at the soil surface may vary widely on imprecisely leveled farmer's fields resulting in a wide variation in the rate of water entry into the soil within a field.

Keeping in view the importance and limited information available, the present study was carried out to determine the effect of ripping and water head on infiltration rate of soils.

Materials and Methods

The study was carried out at Research and Experimental Station, King Faisal University, Hofuf, Al-Hassa, Kingdom of Saudi Arabia during July-August, 2001. Two sites varying in texture (sandy loam and clay loam) were selected under the command of Well No. 1. Normal soils were selected to minimize the effect of excess soluble salts and exchangeable sodium in soils. The physico-chemical analysis of soils are given in Table 1.

Experimental procedure

Preparation of experimental site: The selected sites were irrigated with deep groundwater (pH 7.35, EC 2.5 dS m^{-1} and sodium adsorption ratio (SAR) 2.75 and allowed to stay for about two weeks to bring the soil moisture close to dryness. After complete drying, the sites were precisely leveled with the help of a wooden plank run by a tractor. The sites were divided into 20 x 10 m^2 blocks and replicated three times. In all, there were 48 plots for the experiment.

Treatments: The treatments involved were two soil types (Sandy loam and Clay loam), four water heads (5, 10, 15 and 20 cm depths) and two soil treatments (control and ripping). Each treatment was replicated three times. A Complete Randomized Block Design was followed for laying out the experiment.

Application of ripping treatment: The sites were ripped with a chisel plow up to 60 cm depth to open the soil below surface where the hardpan was present in the upper 50 cm depth of soil. After treatment, the sites were again leveled with a wooden plank for the measurement of infiltration rates of soils.

Measurement of infiltration rate of soils: The infiltration rate measurements were taken by following the procedure as described in the USDA Handbook No. 60 (1954) and by Aronovici (1955). The infiltrometers were 45 cm long with an inner diameter of 30 cm, whereas, the buffer rings were 45 cm long with an inner diameter of 50 cm. The infiltrometers were inserted into the soil up to 15 cm depth as vertical as possible to form a tight bond between the infiltrometer ring and the soil. Similarly, buffer rings were also placed outside the infiltrometers to counter the effect of lateral movement of water. The infiltration rate was measured with four different levels of water head. The treatments consisted of 5, 10, 15 and 20 cm depth of water in each ring at each site in different type of soils and replicated three times.

The water used for measurements was the same as that being used to irrigate the fields. The infiltration rate measurements were carried out on dry soil and repeated three times on each site. Plastic sheets were placed inside the ring before water addition to avoid soil disturbance. The water intake readings were recorded at 10, 20, 30, 40, 50 and 60 minutes time period. The water level was maintained to its original position after a drop of 2-3 cm level in the water head. There were in all 6-measurements for water

Table 1: Physical and chemical analysis of experimental soils

Site No.	pH	Ece dS m^{-1}	SAR	Clay	Silt	Sand	Textural class
					%		
1	7.85	2.25	4.2	13	12	75	Sandy loam
2	7.95	1.85	4.25	29	42	29	Clay loam

Table 2: Comparison of water head on infiltration rate of soils

Treatments	Water head (cm)			
	5	10	15	20
Sandy Loam				
Control	4.38 a	5.63 a	7.00 a	8.13 a
Ripping	5.79 b	7.84 b	9.90 b	13.22
Clay Loam				
Control	1.51 a	2.36 a	2.68 a	3.28 a
Ripping	2.23 b	3.22 b	3.90 b	4.76 b

Figures in a column followed by the same letter are not significantly different by $LSD_{0.05}$.

infiltration rate with the first taken after 10 minutes followed by 10-minutes increments till the water infiltration almost reached steady state. Three measurements were recorded at each site and the mean data were presented to evaluate different experimental treatments. The data were analyzed statistically following ANOVA as described by Snedecor and Chochran (1973).

Results and Discussion

Effect of water head on infiltration rate of sandy loam soil

Control plots: Depending upon different water head treatments, mean infiltration rate of soil in the control plots without ripping treatment decreased significantly with time (Fig. 1). The ranges for mean infiltration rate were: 11.4-1.25 cm hr^{-1} (5 cm), 15-1.55 cm hr^{-1} (10 cm), 18-2.65 cm hr^{-1} (15 cm) and 21-3.1 cm hr^{-1} (20 cm) with a uniform time interval of 10 minutes between the initial and the successive measurements. Overall, mean infiltration rate of soil came to 4.38 cm hr^{-1} (5 cm water head), 5.63 cm hr^{-1} (10 cm water head), 7.00 cm hr^{-1} (15 cm water head) and 8.13 cm hr^{-1} (20 cm water head) in different treatments. The mean infiltration rate of soil increased significantly with an increase in water head ($LSD_{0.05}$ = 0.560). The R^2 (Coefficient of Determination) value of 0.982 indicates that infiltration rate of soil is directly related to the soil type, actual water needs of the crops and the water head of applied irrigation. This phenomenon of deep percolation losses of irrigation water could be more pronounced in those fields which are not properly leveled and the depth of water applied is highly variable in different parts of the field. The research findings agree with those of Eric (1962) who observed significant differences in water infiltration of soils between water head of 2.5 to 15 cm on high infiltration rate soils. Similar results were obtained by Schiff (1953) and Aronovici (1955) who concluded that the increase in infiltration rate of soils was directly proportional to an increase in water head.

Ripping Treatment Plots: Mean infiltration rates of soil ranged between 2.15-13.14 cm hr^{-1} (5 cm), 18.78-2.15 cm hr^{-1} (10 cm), 24.36-3.50 cm hr^{-1} (15 cm) and 31.50-4.95 cm hr^{-1} (20 cm) in different water head treatments (Fig. 2). Overall, mean infiltration rate of soil came to 5.79 cm hr^{-1} (5 cm water head), 7.84 cm hr^{-1} (10 cm water head), 9.90 cm hr^{-1} (15 cm water head) and 13.22 cm hr^{-1} (20 cm water head) in different treatments. Mean infiltration rate of soil increased significantly with an increase in water head of applied water ($LSD_{0.05}$ = 0.852). The R^2 (Coefficient of Determination) value of 0.988 means that infiltration rate of soil was directly related to the depth of irrigation water applied. The difference in mean infiltration rate of soil was significant between the ripping and the control treatments. The magnitude of increase was of the order of 132 to 163 % in various treatments. The results are comparable with those of Pikul *et al.* (1992) and Wilkins *et al.* (1991), who stated that ripping increased the infiltration rate of soil substantially when compared with the control treatment.

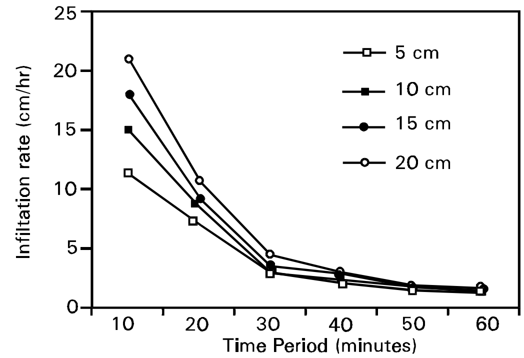

Fig. 1: Effect of water head on infiltration rate of sandy loam soil

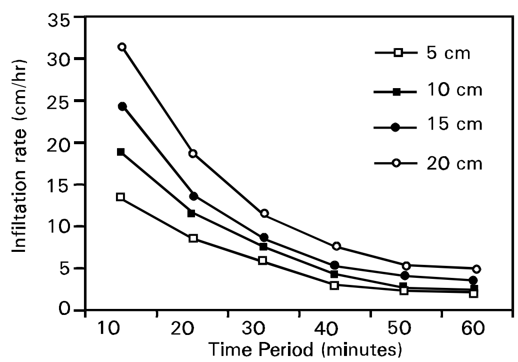

Fig. 2: Effect of ripping and water head on infiltration rate of sandy loam soil.

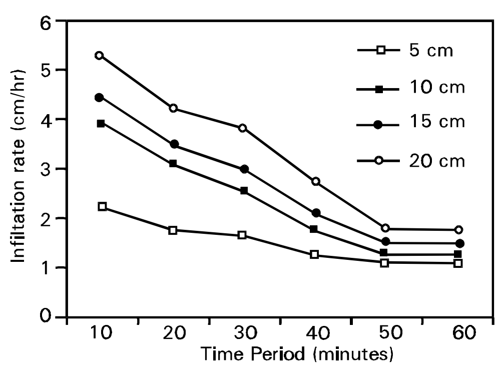

Fig. 3: Effect of water head on infiltration rate of clay loam soil

Effect of water head on infiltration rate of clay loam soil

Control plots: Depending upon different water head treatments, mean infiltration rate of soil decreased significantly with time (Fig. 3). The ranges for mean infiltration rate were: 2.22-1.1 cm hr^{-1} (5 cm), 3.95-1.25 cm hr^{-1} (10 cm), 4.46-1.50 cm hr^{-1} (15 cm) and 5.28-1.75 cm hr^{-1} (20 cm) in different water treatments. Overall, mean infiltration rate of soil came to 1.51 cm hr^{-1} (5 cm water head), 2.36 cm hr^{-1}(10 cm water head), 2.68 cm hr^{-1} (15 cm water head) and 3.28 cm hr^{-1} (20 cm water head) in different treatments. The mean infiltration rate of soil increased significantly

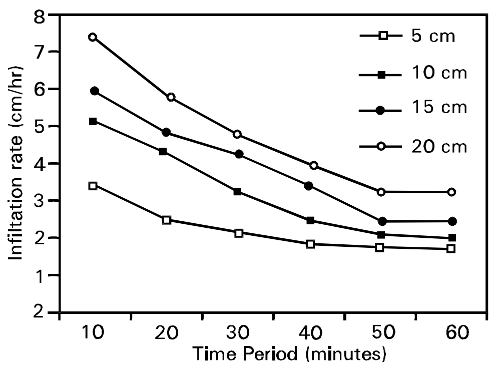

Fig. 4: Effect of ripping and water head on infiltration rate of clay loam soil

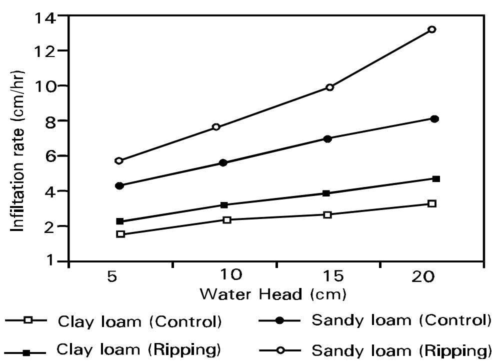

Fig. 5: Comparison of water head and ripping on mean infiltration rate of soils.

with an increase in water head of applied water ($LSD_{0.05}$ = 0.089). The R^2 (Coefficient of Determination) value of 0.997 indicates that infiltration rate of soil is directly related to the depth of irrigation water applied. Similar results were reported by Eric (1962), who observed significant differences in water infiltration of soils between water head of 2.5 to 15 cm on high infiltration rate soils. Also, Schiff (1953) and Aronovici (1955) stated that an increase in infiltration rate of soils was directly proportional to an increase in water head. This suggests that deep percolation losses of the applied irrigation water could be much higher than the actual water need of the crop and moisture storage capacity of the soil under cultivation. This aspect could be more pronounced in those fields which are not properly leveled thus resulting in variable depth of applied water in different parts of the field.

Ripping treatment plots: Mean infiltration rate of soil ranged between 3.45-1.70 cm hr^{-1} (5 cm), 5.15-2.00 cm hr^{-1} (10 cm), 5.95-2.45 cm hr^{-1} (15 cm) and 7.40-3.25 cm hr^{-1} (20 cm) in various water head treatments (Fig. 4). Overall, mean infiltration rate of soil came to 2.23 cm hr^{-1} (5 cm water head), 3.2 cm hr^{-1} (10 cm water head), 3.90 cm hr^{-1} (15 cm water head) and 4.76 cm hr -1 (20 cm water head) in different treatments. The mean infiltration rate of soil increased significantly with an increase in water head of applied water ($LSD_{0.05}$ = 0.0.207). The R^2 (Coefficient of Determination) value of 0.993 means that infiltration rate of soil was directly related to the depth of irrigation water applied. Mean infiltration rate of soil was significantly higher in ripping treatment than the control treatment and the magnitude of increase was between 136 and 146 % in various treatments.

The study findings are comparable with those of Pikul *et al.* (1992) and Wilkins *et al.* (1991) who stated that ripping increased the infiltration rate of soil substantially when compared with the control treatment.

Comparison of water head vs infiltration rate of soils: An analysis of variance was run to compare the effect of different water head treatments on infiltration rate of soils (Fig. 5 & Table 2). It was found that the difference in the mean infiltration rate of soils was significantly higher in the ripping treatment than the control treatment and was applicable for both soil types. This suggests that ripping operation opened the soil profile by breaking the hard layer underneath the soil surface thus resulting in more water infiltration into the soil.

Mean infiltration rate of soil increased significantly with an increase in water head in both sandy loam and clay loam soils. Mean infiltration rate of sandy loam soil ranged between 4.35-8.13 cm hr^{-1} for the control treatment and 5.79-13.72 cm hr^{-1} in the ripping treatment in different water head treatments. Similarly, mean infiltration rate of clay loam soil ranged between 1.51-3.28 cm hr^{-1} (control) and 2.23-4.76 cm hr^{-1} (ripping) in different water head treatments. The ripping of soil and water head significantly increased the infiltration rate of soil than the control treatment. The magnitude of increase in the infiltration rate was 132-163 % in sandy soils and 136-146 % in clay loam soil in different treatments.

In conclusion, ripping of soil provided an excellent opportunity for speedy reclamation of salt affected lands by improving the infiltration rate of soil. The positive effect of increasing water head on the infiltration rate of soil warrants the scientific irrigation scheduling to replenish the moisture storage capacity of soil to meet crop water needs for optimum production. It would also minimize deep percolation losses to improve the water conservation and management in an arid environment.

References

Abo-Abda, A. and G. Hussain, 1991. Impact of machinery compaction and tillage systems on Infiltration rate of sandy soils. Arid Soil Research and Rehabilitation, 4: 157-162.

Al-Ghazal, A.A., 2000. Effect of tillage practices and compaction on infiltration rate of sandy soils. Pak. J. Biol. Sci., 3:1443-1446.

Aronovici, V.S., 1955. Model study of ring infiltrometer performance under low initial soil moisture. Soil Sci. Soc. Amer. Proc., 18:1-6.

Eric, L.J., 1962. Evaluation of infiltration measurements. Trans. ASAE Vol., 5: 11-13.

Philip, J.R., 1958. The theory of infiltration. VI. Effect of water depth over soil. Soil Sci., 85: 278-286.

Pikul, Jr. J.L., L. F. Zuzel and D.E. Wilkins, 1992. Infiltration into frozen soil as affected by ripping. Trans. Amer. Soc. Agric. Engr., 3591: 83-90.

Schiff, L., 1953. The effect of surface head on infiltration rates based on the performance of ring infiltrometers and ponds. Trans. Am. Geophys. Un., 34: 257-266.

Snedecor, G.W. and W.G. Cochran, 1973. Statistical Methods, 6th ed. Iowa State University Press, Amer. IA.

Wilkins, D.E., J.L. Pikul Jr., J. F. Zuzel and R.W. Smiley, 1991. Tillage tool for enhancing water infiltration through frozen soils. P 393-398. In T. J. Gish and A. Shirmohammadi (ed) Preferential Flow. Proc. National United State Salinity Laboratory Staff. 1954. US Department of Agriculture, Handbook No. 60 Washington, DC.